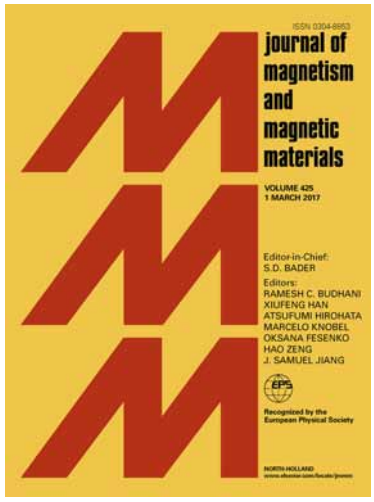

Alternating Magnetic Field Plate for Enhanced Magnetofection of Iron Oxide Nanoparticle Conjugated Nucleic Acids

Murat Kaya Yapici, Ahmad Al Nabulsi, Nahla Rizk, Selwa Mokhtar Boularaoui, Nicolas Christoforou, Sungmun Lee

PII: S0304-8853(18)31476-8
DOI: https://doi.org/10.1016/j.jmmm.2018.09.038
Reference: MAGMA 64320

To appear in: *Journal of Magnetism and Magnetic Materials*

Received Date: 15 May 2018
Revised Date: 30 August 2018
Accepted Date: 7 September 2018

Please cite this article as: M. Kaya Yapici, A. Al Nabulsi, N. Rizk, S.M. Boularaoui, N. Christoforou, S. Lee, Alternating Magnetic Field Plate for Enhanced Magnetofection of Iron Oxide Nanoparticle Conjugated Nucleic Acids, *Journal of Magnetism and Magnetic Materials* (2018), doi: https://doi.org/10.1016/j.jmmm.2018.09.038

Alternating Magnetic Field Plate for Enhanced Magnetofection of Iron Oxide Nanoparticle Conjugated Nucleic Acids

Murat Kaya Yapici [1,2,3,*], Ahmad Al Nabulsi [4], Nahla Rizk [5], Selwa Mokhtar Boularaoui [5], Nicolas Christoforou [6], Sungmun Lee [5]

[1] Faculty of Engineering and Natural Sciences, Sabanci University, Istanbul 34956, Turkey
[2] Department of Electrical Engineering, University of Washington, Seattle, WA 98195, USA
[3] Sabanci University Nanotechnology Research and Application Center, Istanbul 34956, Turkey
[4] Department of Computer Science and Engineering, American University of Sharjah, Sharjah 26666, UAE
[5] Department of Biomedical Engineering, Khalifa University, Abu Dhabi 127788, UAE
[6] Humacyte Inc., Durham, NC 27709, USA

Abstract

Magnet-assisted transfection or magnetofection refers to the delivery of nucleic acids to target cells with the help of conjugated superparamagnetic iron oxide nanoparticles (SPIONs) and external magnetic fields generated by permanent magnet plates. The external magnetic field, among other parameters, directly affects the transfection efficiency. However, standard permanent magnet plates generate static magnetic fields which are not as effective compared to time-varying, dynamic fields. In this work, we show a new and novel "AC magnet plate" compatible with standard 96-well cell culture plates, which can be easily adapted for benchtop use in a typical lab setting. We provide full design details, modelling, fabrication, measurement and testing on human embryonic kidney cells (HEK 293) to show transfection improvement. We perform magnetofection under different field conditions and show that with increasing AC content, efficiency of transfection is improved.

Keywords**:** magnetofection, alternating field, dynamic field, oscillating field, gene delivery, nucleic acid, magnetic transfection, magnet plate, electromagnet, AC, superparamagnetic iron oxide nanoparticle, SPION, HEK 293.

1. Introduction

Mutations or absence of essential genes such as cancer suppresser genes have serious complications on the human well-being. As technology in medicine is developing, new treatments for genetic disorders are emerging, referred to as gene therapy. Due to advances in the human genome project, gene therapy is now a promising method for the treatment of genetic disorders and diseases by way of replacing missing or malfunctioning genes with new, healthy genes. However, the efficacy of gene therapy is directly correlated with the ability to deliver the desired genes to cells, which calls for the development of robust gene delivery techniques.

So far, many gene delivery techniques were developed to introduce plasmid DNA, small interfering RNA (siRNA) or duplex RNA, oligonucleotides, and RNA into eukaryotic cells [1]. Among the various gene delivery techniques non-viral methods are collectively referred to as transfection. Some major transfection methods include lipofection (using liposomes), sonoporation (using ultrasound), cell-squeezing, electroporation (application of electric field), biolistic delivery with gene gun, mechanical microinjection and magnet-assisted transfection (magnetofection).